

SANDSCAPES

Q RAIN SHADOW

Q SAND STORMS

Q SHIELD DESERTS

DESERTS OCCUR IN EVERY continent of the Earth – including icy Antarctica. Although they share certain characteristics, each desert is the product of forces that combine to make it unique.

Deserts are formed where the influences of climate and weather, geology, geographical location and man's activity combine to make the land desiccated and difficult for unadapted living things.

Deserts, as we all know, are dry, arid places. But lands can still be classified as desert or arid even where there is relatively high rainfall if the rate of evaporation is also high. Thus the driest part of Britain – East Anglia – where the average rainfall is 500 mm a year, would be classified as arid along with the tropical North West of Australia, which has the same average annual rainfall, if it had the same temperatures and sunshine.

Moisture losses

One way of defining deserts is as an area where the vegetation cover is sparse or absent and the ground surface is thus exposed to the atmosphere and the associated physical forces. But this takes no account of evaporation rates.

More accurately, a desert is likely to exist where there is a deficit of moisture because the potential losses from evapotranspiration

The wind sculptured sand of the Sahara desert, Algeria, is an awesome spectacle. The Sahara is the world's largest desert covering 8.4 million kilometres, of which only 11 per cent is sandy terrain.

Tony Stone Photo Library, London





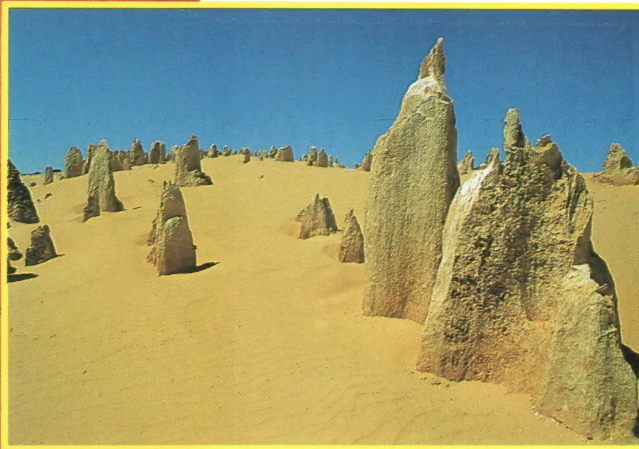
A sandstone arch in Utah, USA. Water seeping into the rock thaws and freezes in the extreme temperatures. As water freezes it expands, causing sandstone to flake off. A hole, once present, is slowly enlarged by water and wind erosion.

fall and where there is no regular annual pattern of rainfall. Then come the arid lands where the potential for ETP vastly exceeds the average rainfall. Finally in semiarid lands the ETP potential exceeds the average rainfall, but not by too much.

Desert belts

It is calculated that 4 per cent of the Earth's surface is hyperarid, 15 per cent is arid and 14.6 per cent is semiarid. This means that approximately one third of the Earth's land surface has a scarcity of water.

It is no coincidence that a great deal of the arid land occurs in certain



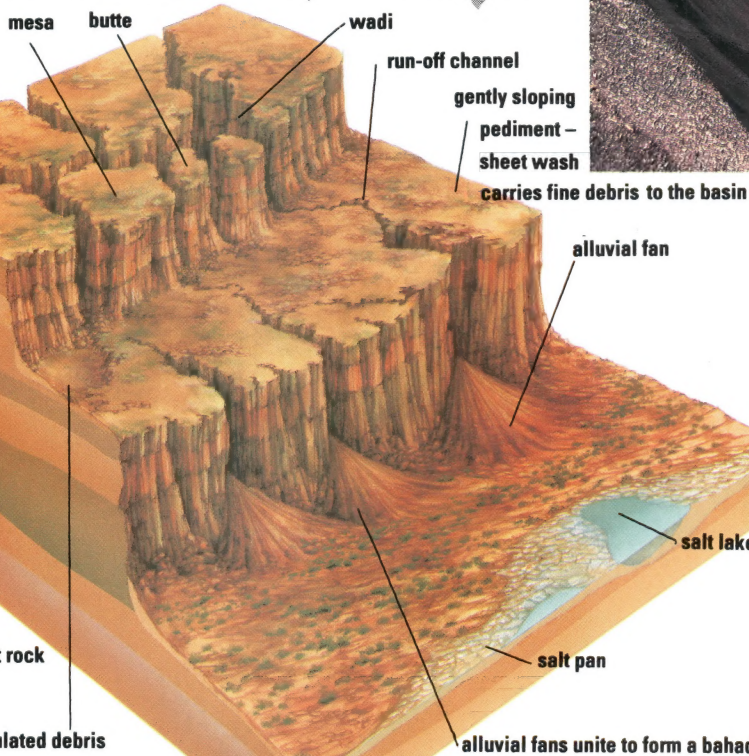
44 per cent of the Australian continent is desert, within which are such diverse geological formations as the limestone pinnacles in Nambung National Park and the Wave rock in Hayden (below), both in Western Australia.

GSF Picture Library

(ETP – evaporation from soils and plant surfaces combined with the transpiration of water from plants) exceed the moisture received from precipitation (rain, dew and snow).

Generally speaking there are three overall degrees of desert aridity. The first is hyperarid land where there have been whole years with no rain-

A cross section of a steep valley, known as a wadi, shows features resulting from erosion, caused by heavy, but rare, downpours known as flash floods.



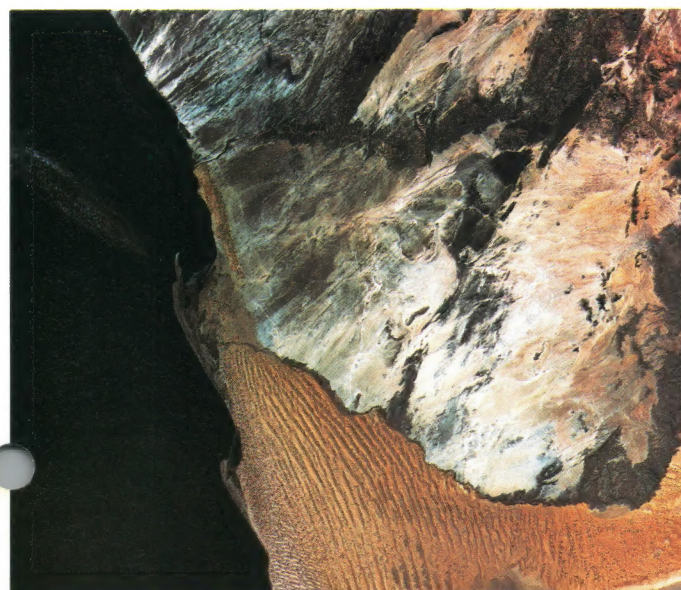
note: vertical scale is exaggerated

fairly well-defined parts of the world. Most of the Earth's desert is found in two belts, one between latitude 15° and 30° north of the equator, the other between latitude 15° and 30° south of the equator.

High pressure zones

The essential cause of this is concerned with how heat from the Sun is spread over the globe, and the movement of air masses resulting from the Earth's rotation. Large volumes of air are heated by solar energy and rise from a region approximately 10° either side of the equator. As the hot air rises it cools and loses its ability to hold water and so rain falls. This is why the area around the equator is usually so wet. The air – now dry – moves towards the poles and descends between latitudes 15° and

Hutchinson Library



Sand dunes are formed into varying geometric shapes according to the characteristics of wind and sand. Only 25 per cent of the world's deserts are covered by wind-blown sand.

The Namib Desert, Namibia taken from a satellite. This view covers about 40,000 sq km and shows a series of sand dunes, swept into parallel lines by off-shore winds, ending at the Kuiseb River.

30° – where the deserts are.

Descending air warms up and is capable of carrying higher moisture content before clouds will form. The descending air creates a high-pressure zone with characteristically stable weather of clear skies, leading to hot sunny days and cool nights in the desert zones. High-pressure zone deserts include the Sonoran desert in North America and the Sahara desert in Africa. There are three such rising and falling 'cells' in each hemisphere.

Another cause of dry air has to do with sea-water currents engendered by the Earth's rotation on its axis.

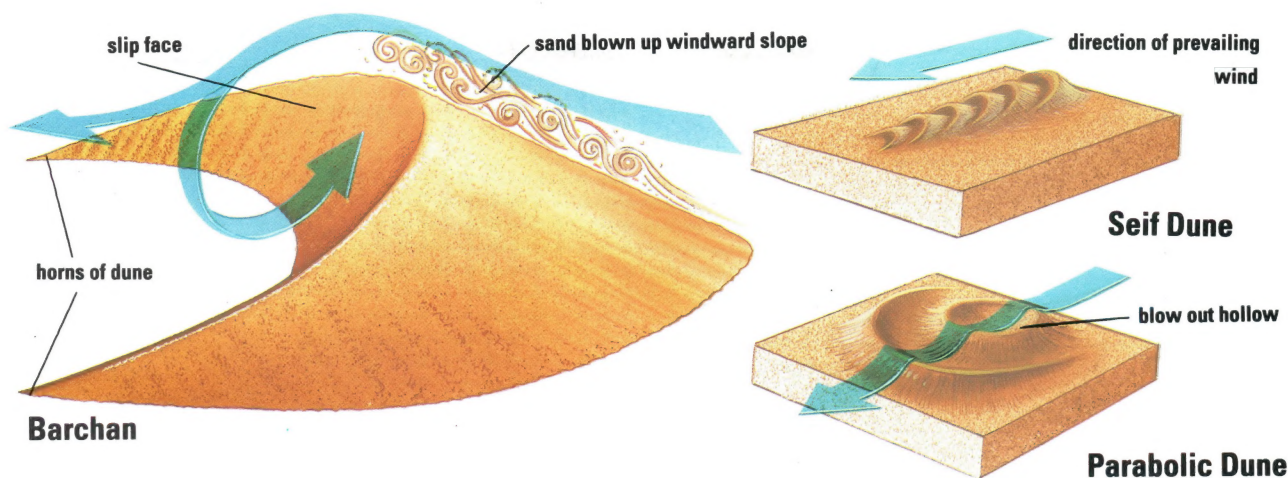
Prevailing winds blowing parallel to a land mass have the effect of blowing the top, warm layers of water out to sea, directly away from the coast. When the top layers are blown away, they are replaced by cold water welling up from the deep ocean, which is added to cold currents that flow from the polar regions towards the equator. The colder surface water due to upwelling seems to reinforce the existing atmospheric stability because of subsidence. Such deserts are often foggy. Examples of coastal deserts caused by upwelling ocean currents are the Atacama desert, Chile and the Namib desert in Africa.



Geographical location

Two other causes of dry air – and thus dry lands – are to do with geographical location. Areas of land that are to the leeward (the sheltered side) of the prevailing wind crossing a mountain range generally get very little rain. As the air crosses the mountains it rises,

The San Juan river in Goosenecks State Park, Utah, USA, shows the erosive power of water, scouring its way through layers of rock to gouge a deep and spectacular canyon.



Simon Critchley

SAND STORMS

The stinging horizontal wall of sand of a sand storm can be so vicious that it strips the paint off vehicles and makes glass windscreens opaque. But sand itself – with its relatively heavy grains – only usually rises up to 2 m in the air even in the worst of sandstorms with very strong winds.

Much more common are dust storms where smaller particles than sand – such as clay and silt – are drawn up into the air by wind. If visibility, reduced by dust in the air, drops below 1,000 m then it counts as a dust storm. Dust blown off the Sahara can travel great distances. In 1982 a 1,600 km long cloud dumped an enormous amount of dust, collected in the Sahara, on Florida, all the way across the Atlantic.

Photographic Library of Australia



cools and cannot hold water, and rain falls on the windward side. The air – now dry – descends on the other side of the range and warms up. This allows it to take up more moisture so that it can readily absorb any water from the land below and rain is unlikely. This effect is known as *rain shadow*. Rain-shadow deserts include the Great Basin area in North America and the Patagonian desert in South America.

The other geographical cause of arid land is simply when an area is so



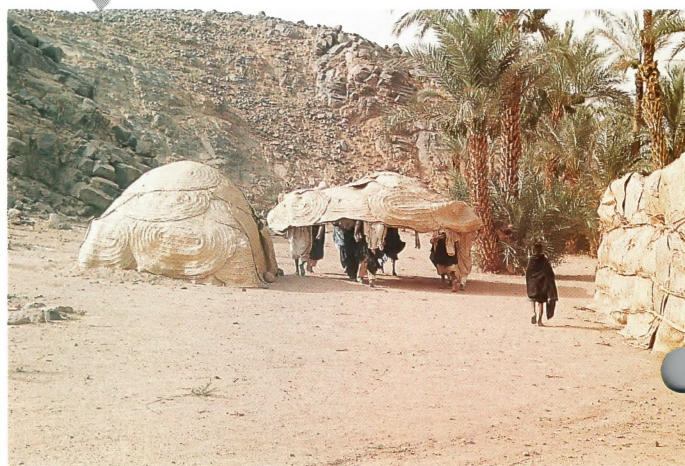
Abu Dhabi is a state of the United Arab Emirates on the coast of the Arabian peninsula. Summer temperatures can reach 49°C and average rainfall is less than 13 centimetres a year.

The Tuareg, a nomadic tribe living in Niger, West Africa, moving house. During the dry months of the year, from October to June, they travel south to find water and land to graze livestock.

HOTTEST AND COLDEST

Some of the hottest air temperatures recorded in deserts have been a scorching 57°C in the Libyan Sahara on 13 September 1922 and a killing 56.7°C in Death Valley, USA during July of 1913. However, in some patches of desert, the air temperature remains below freezing. These are the deserts of the Arctic and Antarctic where the total precipitation is often less than the lowest in warmer deserts. The main cause of these cold deserts is high pressure air from warmer latitudes descending over the poles.

Just to confound the statistics, it has even snowed in the Kalahari. For the first time within living memory, the temperature plunged to -5°C on 1st September 1981 and the drifting sand was covered with drifting snow.



The South Australian outback in bloom after rare rainfall. The plants wither again in dry conditions but when flowering will be pollinated by wind or insects.



Photographic Library of Australia

abrasive particles, is a less dominant cause of rock shaping than water, though it alters the appearance of the desert by its transportation of light materials.

Erosion features in deserts include:

- Desert pavements, where stones provide some protection to the surface and stand clear of finer material such as sand or clay
- Crusts, where minerals are dissolved in water, then dry out to form hard layers
- Closed depressions; gullies, where flash-flood water gouges deep channels in the surface
- Pediments, gently sloping features cut across bedrock around the base of mountains
- Desert lake beds – which are the low-lying areas where any flood water finally ends up.

Where vegetation cover is very low the surface soils can be blown about. Gradually, grains of sand get winnowed out (separated) from mixed deposits of weathered rock, from sea shores and alluvial deposits.

The wind gradually piles up the sand to form dunes. The height, size and shape of the dunes depends on the size of the grains, the wind characteristics and also the varying directions of the wind.

John Wright/Hutchison Library

far away from the sea that moist air never reaches it. Examples of these deserts in the middle of continents include the Gobi Desert in Asia and the Simpson desert in Australia.

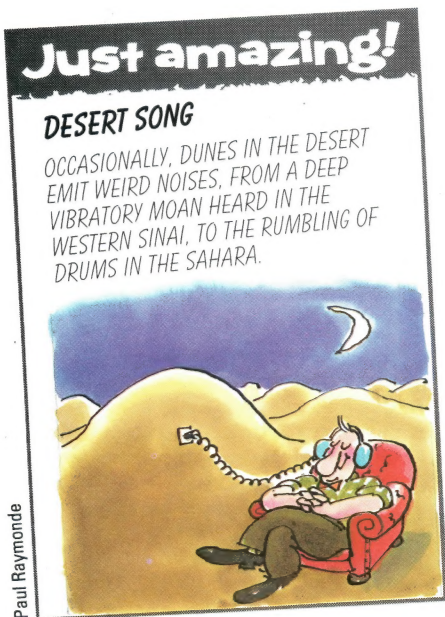
Weathering

There are two basic types of desert: the **mountain and basin desert**, typified by Death Valley in the south-western United States, where mountains rising to over 3,000 metres are close by salt flats lying below sea level; and **shield deserts** such as those in Africa, which tend to have less variation in height across them.

The rocks in the mountainous part of a mountain and basin desert are subject to weathering from salts,

water and temperature change. Frost weathering occurs due to the freeze and thaw of water in high altitude deserts. Insolation weathering occurs due to high temperature ranges in hot deserts, which some scientists argue cause expansion and contraction of rocks leading to break up. The high mountainous deserts experience the most extreme changes.

Where there are no frosts but there are some salts in the rock, these can crystallize from solutions and break up the rocks. Once rock has weathered, wind and water erosion take place. Wind, even armed with



Paul Raymonde

Chaussumier/Jerrican

icy WASTELAND



THE HARSH CLIMATE OF Antarctica makes this continent the most inhospitable on Earth. Antarctica means, literally, 'opposite to the Arctic'. But the two polar regions are very different. The Arctic is a frozen ocean surrounded by land; the Antarctic is a frozen continent, twice the size of Australia, surrounded by the stormiest body of water in the world.

The Antarctic is the coldest, windiest and highest of the world's land masses. It is, in fact, a cold desert. The rate of precipitation in the interior, falling as snow, is less than 50 mm a year – similar to that of most of the world's hot deserts.

Cold desert

Because so little of the snow ever melts, it has built up over hundreds of thousands of years into gigantic ice sheets that cover 98 per cent of the surface of Antarctica – over 14 million square km. An ice sheet radiates outwards from a huge central ice dome. The weight of the dome pushes away the ice on all sides, causing the sheet to slowly move towards the coast and into the sea.

The ice covering the Antarctic varies in thickness from a few hundred metres along the coastline to

more than 4,500 metres in the continent's interior, where its weight depresses the Earth's crust by as much as 1,500 metres. Locked within these sheets is 70 per cent of the world's fresh water.

On the surface, Antarctica is a land of plateaux, mountain ranges that pro-

ject as high as 5,181 metres above the ice and even volcanoes, such as Mount Erebus and Mount Terror. The average height of the continent, 1,830 metres, is six times higher than that of Europe. Gusts of wind reach speeds of over 300 km/h.

Seismic and radar surveys (ice is



Antarctic station Dumont D'Urville. Conservationists from all over the world protested when the base built an air strip on a site that is not only on Adelie penguins' traditional breeding grounds, but also falls across the migratory path of emperor penguins.

A diver plunges into the freezing water beneath an ice sheet off Signy Island in Antarctica. He is attached to a linesman on the surface, who will guide him back to the hole cut in the ice.

Doug Allan/Science Photo Library



transparent to radar) have revealed the hidden landscapes beneath the ice: great troughs, lakes of meltwater and huge sedimentary basins. The Transantarctic Mountains cross the entire continent, dividing it into two.

Continental drift

The geological structure of one side of the continent resembles Australia, South Africa and India, whereas the other side is similar to South America. This supports the theory that many millions of years ago all the continents were part of one great landmass.

Doug Allan/SPL



R Mulvaney/SPL

Technicians erecting aerial masts in preparation for research on the upper atmosphere at the British Antarctic Survey's Halley Station.

At the southern end of the Earth's axis, the point where all the Earth's lines of longitude meet, is the South Pole. But this geographic pole does not coincide with the south magnetic pole, which is found some 1,600 km away, in Adelie Land. The magnetic pole shifts as much as 8 km in a year, in response to changing convection



Simon Fraser/SPL

Glaciologists extract an ice core from the Antarctic ice sheet. Samples taken from different sections of the core (as above) are analysed for data on pollution in the atmosphere and climate changes.

currents within the Earth.

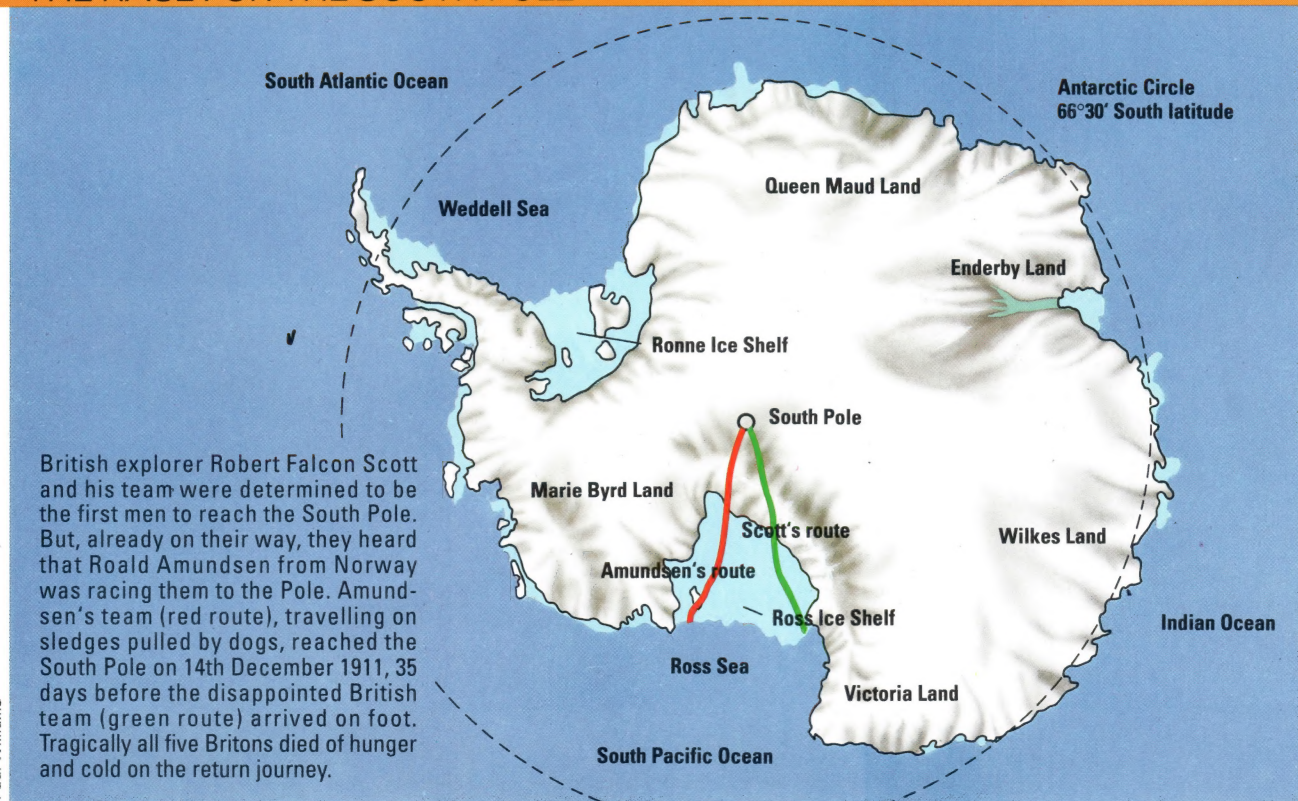
The South (geographic) Pole lies on a massive ice-covered plateau. The highest recorded temperature here is a cool -14°C . The coldest temperature, a bone-shattering -89.2°C , was recorded nearby.

To the Pole

Today, the South Pole is marked by a ceremonial orange-and-black striped pole surrounded by the flags of those nations that have signed the Antarctic Treaty. Nearby is an American scientific base, the Amundsen-Scott station, its buildings sheltered by an aluminium geodesic dome.

Apart from half-a-dozen species of

THE RACE FOR THE SOUTH POLE



Paul Williams





Emperor penguins on the Antarctic coast. The female leaves her egg with the male for eight weeks. She returns just before the egg hatches, freeing the male to fish for his first meal in 60 days. Both parents carry food to the young, taking turns to hunt at sea.

tiny wingless insects, there are no animals or birds that inhabit the Antarctic all year round. There are no trees or shrubs at all. The plants that do survive in the extreme cold – lichens, mosses and just two species of flowering plants – live on rocky outcrops, nourished by guano (bird droppings).

But the antarctic coastline teems with life during its short summer months, when millions of animals descend on the continent,

Huge colonies of seals inhabit the rocky beaches. Flying over the coast, observers can see birds nesting in their thousands while the sky above is swarming with gulls and petrels.

Summer visitors

The most common breeds of penguin are the emperor penguin, which measures 1 metre in height, and the Adelie penguin. Emperor penguins are the last summer visitors to leave the continent, apart from the occasional scientist, as



attracted by an abundance of plankton (microscopic one-celled plants) in the surrounding seas. Shrimplike crustaceans called krill live off the plankton, and are in turn eaten by whales, seals, squid, birds and fish.

Humpback whales grow to 19 metres in length and weigh up to 48 tonnes. They have been hunted so heavily for their meat that now there are only about 10,000 left.

Usnea lichen, one of the few organisms that live in Antarctica all the year round. A film of ice shelters the lichen, while allowing light to pass through.



Just amazing!

WATCH YOUR STEP

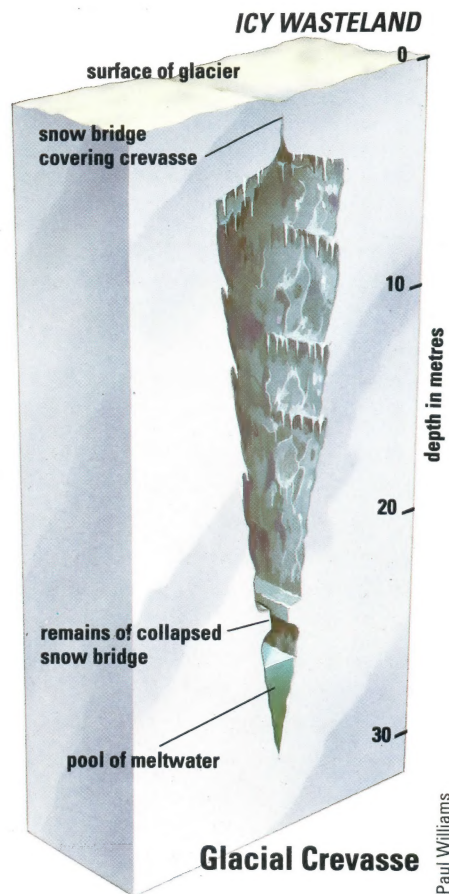
THE COLD OF THE ANTARCTIC SLOWS REGROWTH DOWN SO MUCH THAT A BED OF MOSS CAN TAKE OVER TEN YEARS TO RECOVER FROM THE DAMAGE OF JUST ONE FOOTSTEP.



the freezing winter sets in.

In 1961, under the Antarctic Treaty, the Antarctic was declared an international protectorate. All territorial claims by different nations were suspended. Antarctica is now a nuclear- and military-free zone where scientific teams from many nations can work, so long as they make their findings freely available.

The Antarctic's biggest and most



The brittle upper crust of a glacier may split to a depth of up to 30 metres when the glacier moves over a hump in the bedrock.

obvious resource is its ice, of which the continent is estimated to contain more than 28 million cubic km. This represents the world's largest resource of fresh water. In fact, Antarctica contains over 90 per cent

of all the Earth's glacial ice. Scientists are already working on ways to tow icebergs northwards to supply the needs of the world's hot deserts.

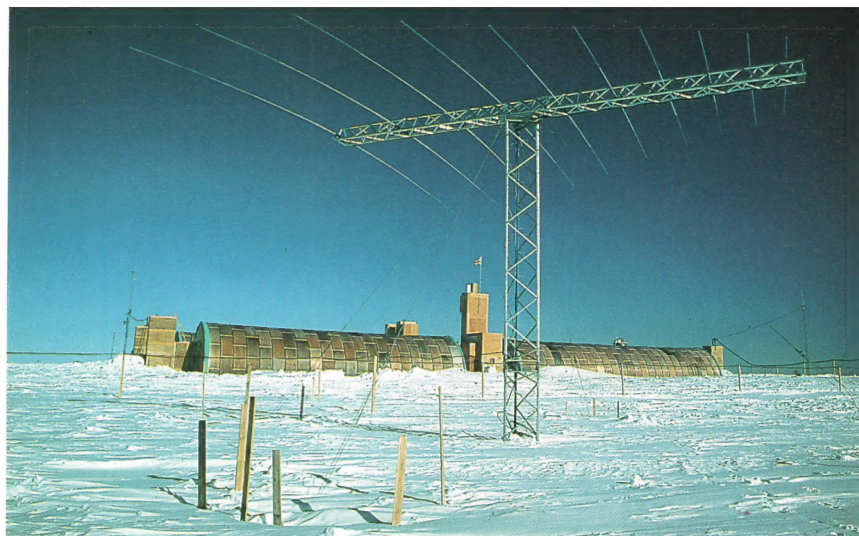
Recent research suggests that vast deposits of coal, iron, copper, lead, tin and even platinum lie under the ice sheets. There may be oil under the Ross Sea. Near the Transantarctic Mountains is a coal field that may be the largest in the world. Close to the



coast facing the Indian Ocean is a deposit of iron ore 120 km long and 100 metres thick. A meeting of Antarctic Treaty Nations in 1991 agreed to ban all mineral and oil exploitation for 50 years. This superseded an agreement in 1988 which would have permitted limited mining.



A scientist on the roof of a base takes a reading from a Dobson machine, which measures the size of the hole in the Earth's ozone layer. The bulk of the machine is in the room below.



Doug Allan/SPL

Halley Station. Behind the giant antenna (one of 16) are tube-like structures made of wood, designed to protect living quarters and working areas when the entire station is buried by snow.



Hunting and fishing

Midgley/Greenpeace

Although no mining has yet taken place, Antarctica is already being exploited in other ways. In coastal waters, massive factory ships scoop up enormous catches of fish, raising concern about over-fishing. Whales have been hunted in the seas around the Antarctic to the point of near-extinction. Seals, too, have been hunted in great numbers.

Because of growing concern to protect Antarctica, the environmental group Greenpeace has been lobbying Antarctic Treaty members to gain

MELTDOWN

Scientists are worried that if the world's climate becomes warmer, the Antarctic ice cap will slowly turn to water. Because Antarctica is so cold, little of its surface ice ever melts. But the sea melts the underside of the gigantic ice shelves that skirt 30 per cent of the continent, causing icebergs to break off and float northwards. An example of this occurred in 1995, when an iceberg the size of Oxfordshire broke free from the Larsen Ice Shelf.

Temperatures in this area of Antarctica are estimated to have risen by 2.5°C in the last 50 years.

support for its proposal that the continent be declared the first World Park, free from economic exploitation. This idea is slowly gaining support. If adopted, it will be a great step forward in protecting this unique land and its inhabitants.

INTO THE FUTURE

POLAR HOLIDAYS



▲ The scenic wonders of Antarctica will make the continent an attractive holiday resort. Visitors might stay in high-rise hotels, approachable only from the air.

▲ From so high up, visitors can enjoy spectacular views of the scenery and the undisturbed wildlife. And in summer, daylight will be almost continuous.

▲ Tourists on excursion trips will be protected from the harsh climate. At the same time, their activities will pollute the environment as little as possible.

Q MOBILE FORCES

Q TANKS

Q AIR COVER

DUNE WARS



You can run but you can't hide in the desert. Lack of cover means troops are constantly exposed to artillery and air strikes. This led to massive casualties in the Iran-Iraq War.

THE DESERT ENVIRONMENT is the most demanding of all in which to fight. In hot, steamy jungles, at least there is shade and water. In freezing polar regions, it is possible to keep warm with the right clothing and there is no problem about water. But many of the world's potential battle fields seem to be in desert areas.

Desert defence is as difficult as attack. These Arab ground troops are exposed to blistering temperatures as they wait for Saddam Hussein's Iraqi forces.

The highest natural air temperatures on Earth have been recorded in deserts. In the summer months, day temperatures can range between 45°C and 50°C. Metal exposed to the direct rays of the mid-day Sun can become hot enough to fry an egg on.

In some deserts, temperatures below freezing can be recorded at night at certain times of the year. Rain-

Gamma/Frank Spooner Pictures

S Ferry/Gamma/Frank Spooner Pictures



fall is usually less than an average of 250 mm a year and this can fall over a very short period of time. Winds can blow steadily throughout the year or occur suddenly with hurricane force.

Although visibility is generally good, at certain times of the day and in particular atmospheric conditions visibility can be reduced by heat haze to a few hundred metres. Sandstorms, which may blow for days,



Artillery has to be well camouflaged as it is very vulnerable to attack from the air. However, it is very effective against land forces. In the desert, it is often possible to see exactly where your shells are falling and adjust your range (left) until they hit the target.

Anti-tank Guided Missile (ATGM) – particularly if mounted on a helicopter such as the US Apache, the Soviet Hind or the British Lynx – has challenged the tank's supremacy of the desert battlefield in recent years.

Target location

Artillery is also very effective in the desert. Targets are easy to locate and fire is relatively simple to adjust as the fall of shot can be seen clearly. However, artillery itself can easily be located, especially from the air.

Whoever achieves mastery of the air in desert conflict is likely to win the battle. Ground targets are particularly vulnerable in open desert. They have little opportunity to conceal themselves as they would, for instance, in North-West Europe. So the key to land tactics is fast-moving, mobile, tracked armoured formations striking decisively and deep, if possible under the

During the desert conflict between Iran and Iraq, gas was used. So American and Allied troops facing Iraqi forces practise wearing gas masks.



pick up surface dust and reduce visibility to a few metres. The dust forms a hot, solid fog which is not only unpleasant but also restricts movement and observation.

The terrain can be flat but in some areas wind blowing from a particular direction over a long period of time leads to a pattern of sand dunes that

first may result in dizziness and even mental confusion. But rest in the shade with water to drink brings about rapid recovery.

The second is brought about by depletion of salt from the body and occurs gradually, after heavy sweating. The symptoms are slowly increasing fatigue, nausea, vomiting and headaches. The condition can usually be relieved by drinking water and eating salt.

Danger of death

Heat stroke is the most serious danger. It is caused by a breakdown of the heat regulating system of the body. When the body loses its ability to cool itself by sweating, its temperature will rise to a dangerous level and can result in death. It is vital that body temperature is reduced by active cooling with water, or ice if available. The daily water requirements for a man vary with the degree of physical activity, his diet and the temperature.

Tactics in the desert are influenced by the generally good visibility, the good fields of fire, the good driving conditions for tracked vehicles at least, the difficulty of constructing field defences and the absence of dominating terrain features. To take advantage of these, mobile forces are used. They are able to cover the large spaces of the desert and can make use of their mobility to protect themselves against attack.

These mobile armoured forces and the tank will be the dominating weapon. In both the Iran-Iraq war in the 1980s and in the Iraqi invasion of Kuwait in 1990, the tank was the crucial weapons system. However, the

DESERT CONFLICTS

There have been three desert wars between Egypt and Israel in the Sinai – in 1956, 1967, and 1973. Israel and Syria clashed in 1967 and 1973 on the Golan Heights.

For eight years in the 1980s, Iran and Iraq fought in the desert along their common border. In 1990, when Iraq annexed Kuwait, the initial sweep came through the desert. In North Africa, Libya and Chad clashed in the southern Sahara in 1989, a dispute resolved in 1994. And a desert war continues in the Western Sahara, an area annexed by Morocco in 1976.

can form giant sand hills up to 300 metres high. On top of these problems, the soldier faces the difficulty of finding water.

Water plays a very important role in maintaining the temperature of the body and its chemical activities. The efficiency of the body is degraded by the loss of fluid and a great loss can be fatal. Heat illness can take three forms, which may be seen separately or in combination: heat exhaustion, salt deficiency and heat stroke. The

Stevens/Sipa/Rex Features



ment that can fix a position very precisely but such equipment is expensive and is not widely available.

Where there are virtually no features at all, the best way to navigate is by dead reckoning. The technique is to drive or march on a bearing and note the distance covered.

Driving in the desert requires special training. Obviously, wheeled vehicles are the more difficult to control in deserts but even tracked

DEBRIS OF WAR

Some of the greatest battles of the Second World War were fought over Egyptian and Libyan territory between 1940 and 1942. Thousands of tanks, vehicles and aircraft were deployed there. Many were destroyed in battle. The arid climate has preserved these hulks to a remarkable degree. The Libyans soon discovered they had a valuable scrap heap in their back yard. For many years this scrap metal contributed massively to the Libyan economy.

protection of superior air cover.

Navigation in the desert is not easy. Because of the lack of terrain features – roads, tracks and landmarks, which can be used to fix a position on the map – it is always difficult to find a way across country. It is possible to have sophisticated navigation equip-

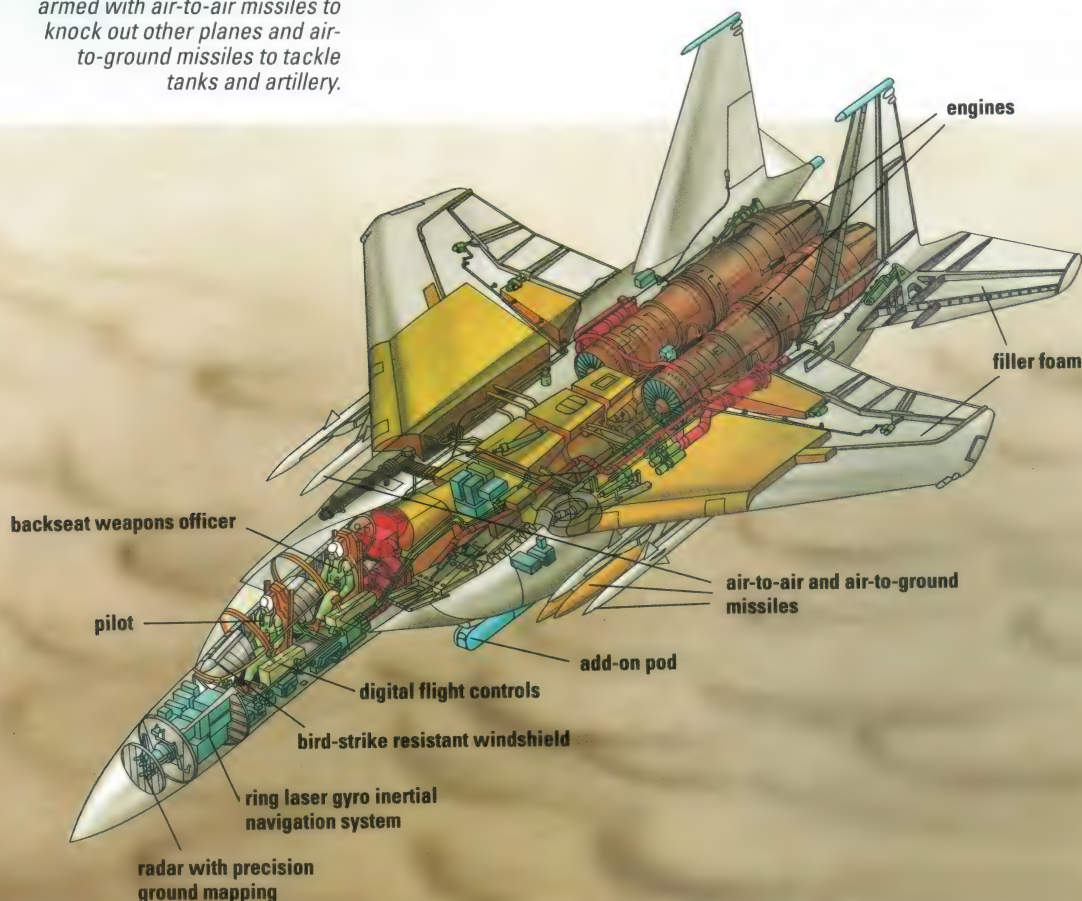
Tanks are the kings of desert warfare. They can move swiftly over sandy terrain, often outflanking the enemy. However they are vulnerable to attack from missile-carrying helicopters.

Hellfire is a laser-guided anti-tank missile carried on the US Army's Apache helicopter. Newer versions have a computerized autopilot and electronics to outsmart countermeasures.



The F-15E aims to be master of the skies over the desert. It is armed with air-to-air missiles to knock out other planes and air-to-ground missiles to tackle tanks and artillery.

F-15E Dual Role Fighter



TRH Pictures/Martin Marietta

McDonnell Douglas/Trevor Hill





vehicles can slip and bog down in very deep sand. Drivers have to make the best use of the momentum of the vehicle to get over difficult ground and must keep the vehicle moving by skilful gear changing and avoiding sudden braking. Furthermore, tyre pressures can be lowered to improve traction in soft sands.

A DESERT STILL

To make a desert still, a hole is dug in the ground in an unshaded place. It should be round and about one metre in diameter. The sides of the hole should slope inwards. A plastic sheet is laid over the hole and secured with dirt and stones to make a good seal. A small rock is placed in the middle of the sheet to weigh it down so that it is about 50 mm above the container. Ideally, there should be 50 mm between the plastic sheet and the surrounding earth. The plastic should not touch the soil or the bucket, or water may be lost.

The still works on the principle that the heat of the Sun raises the temperature of the air and soil under the plastic sheeting to such an extent that any water in it vaporizes. When the air under the plastic becomes saturated – that is, when it can hold no more water vapour – the vapour condenses on the underside of the plastic and runs down into the collecting container. At night as air temperatures fall, the plastic sheet cools while soil temperatures remain high, water vapour continues to condense on the underside of the plastic.

The amount of water produced over a 24 hour period is likely to be at least half a litre and may be as much as one litre. The water collected will taste flat but, as it is distilled, it is safe to drink. Brackish or salty water can be distilled using this method by soaking the ground around the still, while taking care not to let it come in contact with the plastic or get into the container. If it should rain, the plastic sheet also provides means of collecting water.

The careful selection of the route by the driver and travelling at the appropriate speed for the conditions will avoid many disasters. In rocky areas, heavy wear is caused on tyres, tracks and vehicle suspensions. Tyre pres-

Water is always a problem in arid wastes. A person needs more than twice as much water in the searing heat of the desert, even at rest. Drinking when you are wearing a gas mask causes some problems (above) – though it would be a mistake to take your gloves off.



Gamma/Frank Spooner Pictures

Complete head-to-toe cover is needed to protect ground forces against biological weapons. Chemical warfare has already been employed by Iraq.

sures can be reduced to ease the bumping effect, but if taken too low can cause tyres to burst. If a driver hits a rock it can break an axle, engine sump or the suspension.

Soft sand

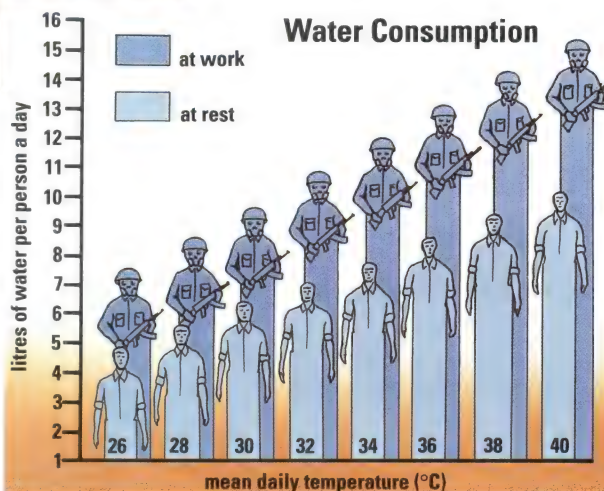
If a vehicle follows tracks in soft sand, there is a danger that it will stall or bog down. The vehicle should be kept moving as sudden stops and starts will cause, first, wheel slip and then bogging down. Channels and sand mats can be used to extricate a vehicle which is stuck.

To do this, you dig the sand out

from in front of the wheels to make a slope. One end of the channel is placed against the bottom of the tyre. Then you drive the vehicle out. Hopefully you can maintain the momentum until the vehicle reaches firm ground.

Bogging down

In very poor conditions, when the vehicle has become seriously bogged down, a considerable amount of digging may be required to extricate it. A



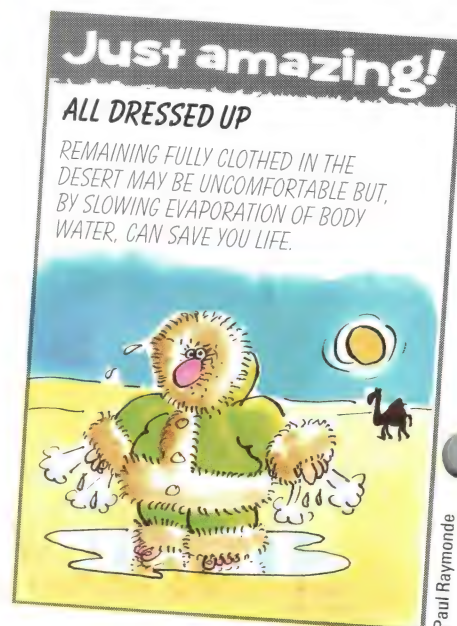
Mark Franklin

vehicle that has sunk until it is resting on its frame may have to be jacked up and packing placed underneath it.

Dune driving

In sand dunes, the crust is often hard and, particularly during the early morning, can provide a stable surface, which will take the weight of a vehicle. But, if the crust is broken by braking or any violent movement, there is a danger that the vehicle will become stuck.

Dunes can usually be crossed by tracked and light vehicles. Everything depends on the skill of the driver, the firmness of the crust and the steepness of the slopes.



Paul Raymond

- Q IDITAROD TRAIL
- Q INFERNO
- Q HAWAII IRONMAN

Wacky Racers

THROUGHOUT HISTORY, man's competitive nature has led to many different types of races – whether running, swimming or walking. They may be over 100 metres, a marathon of 42 km or all the way around the world.

The Iditarod Trail is a race between teams of men or women driving sleds pulled by huskies, and it covers 1,188 km through the frozen wastes of Alaska, across mountain ranges, ocean and over large areas of ice. It is one of the greatest tests of endurance that one could imagine.

Frostbite

The race starts in Anchorage, Alaska and finishes at Nome on the Bering Strait. The route actually crosses two mountain ranges and vast expanses of snow and ice, where the temperature has been known to drop as low as -27°C . Added to this is the wind, which can produce a chill factor equivalent to a further -27°C . Any flesh that is exposed in that kind of temperature will suffer from frostbite

Cyclists and runners follow the Paris-Dakar motor rally. They arrive in Dakar two days after the motorized contestants, having covered 6,000 km.

Swimmers depart from Nice, France, photographed from a helicopter, at the beginning of the Triathlon World Championship in 1986.

within about 30 seconds. In 1974, a chill factor of -49°C was recorded.

The condition that the participants fear most is when there is a 'white out'. This is a horrifying type of snow storm where the violently swirling snow makes it impossible to see your hand in front of your face.

At the start of the race there are a total of around 600 huskies. They are very hardy dogs, used to the terrain on which they will have to run, and will literally run until their hearts give out. Up to 15 dogs may die of exhaustion during the race.

The sled that the dogs pull is driven by a 'musher' who has between 10



and 18 dogs in each team. When the competitors pull away from the start line they have no idea when they will see the finish; it has been known for the race to take anything between 10 and 29 days.

Sixth sense

One strictly enforced rule is that the same dogs must be used throughout the race. Nobody is allowed to harness a fresh animal to their sled. If a dog dies during the race, the musher has to carry on. But an entrant must stop when the number of dogs drops below six because it would be cruel to expect so few to carry the strain.

There are various resting places and checkpoints en route but the drivers seldom stop at them. They often continue, guided either by the sixth sense of the leading dog, moon-



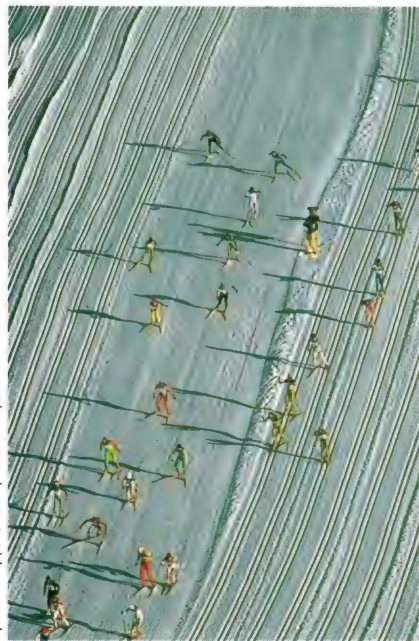
Gamma/Frank Spooner Pictures

marathon. It is an annual event held over 89km; the record time was under four hours. The number of entrants is limited to 12,000 for safety reasons because crowds of skiers through narrow passageways create bottlenecks and increase the chance of injury.

Downhill races are much shorter than cross-country races. The longest one in the world is the Inferno, which is run at Murren in Switzerland. It is from Schilthorn, situated at an altitude of 2,970 m, to Lauterbrunnen, which is 826 m above sea level.

The Inferno

The course is 15.8km long and covers some uphill sections. The inferno is a unique race in a number of ways but the chief ones are that the course is completely unprepared and the racer can choose his own line



Sylvie Chappaz/Vandystadt/Allsport

15,000 skiers took part in the 9th 'Foulee Blanche', an annual long-distance, cross-country ski race in the Alps, near Grenoble.

Differences in Ski Design

Skis, poles, boots and even clothing differ in cross-country skiing and downhill skiing. The length, weight and design of skis and poles is adapted to each discipline.

During the Iditarod Trail race, a distance of 1,800 icy kilometres, the huskies run at about 10 km/h. For the dogs there are approximately 3,000 steps to each kilometre. The dogs are allowed to rest for two hours after feeding (above).



light or a thin torch beam from a miner's-type helmet. When the drivers are exhausted they dig out hollows in the snow known as 'revetments' and sleep on their sleds in feather-filled sleeping bags, wearing six layers of clothes and surrounded by their sleeping huskies.

Also on snow, the Vasa Cross-Country Skiing Race was founded in Sweden in 1922 and is the oldest

across the natural snow, and there are very few controls on the course.

It is a race that only the real experts can compete in as the competitor must be a master of every technique. This means they must be capable of skiing both uphill and down, and over a variety of terrain and types of snow.

As with the Vasa, the number of entrants has had to be limited, in this case to 1,450. Furthermore, because it is a downhill race the competitors have to set off at different times to avoid dangerous overcrowding.

Gamma/Frank Spooner Pictures

lightweight boot



Cross-country Ski Equipment

simple heel clamp

high moulded boot

long curved tip

Downhill Ski Equipment

heel binding

The most common form of racing is running, and one of the most popular events is the marathon. It is run over a distance of 42.195 km, a length standardized since the 1924 Olympic Games.

It was first introduced to the Olympics in 1896 to commemorate the run of Philippides from the battlefield of Marathon to Athens in 490 BC. He ran to bring news of the

Paul Williams



battle, then died of exhaustion.

There are no official times for the fastest marathon. As the courses vary in their severity it is a difficult thing to judge. The highest number of people to have completed a marathon was in

FIELDGUNNING



The Royal Tournament Naval Field Gun Competition was first introduced to this annual military festival in 1907, and has existed with the present rules since 1913. It is a race between teams of naval engineers to disassemble a working field gun, or cannon, and then carry the parts including a barrel weighing 406 kg over a specially constructed course. This includes lifting it over a wall 1.52 m high and then scaling across a chasm 8.53 m wide. Once at the far end, the winner is the fastest team to reassemble the gun and fire a shot from it.

The record time is held by the Portsmouth Command Field Gun crew who completed the course in 2 minutes and 40.6 seconds at the 1984 Royal Tournament at Earl's Court, London, UK.

New York in 1992, when the total number of finishers was 27,797. A record 105 men completed the course in under 2 hours and 20 minutes.

In 1984 the first Olympic Marathon for women took place in Los Angeles and nine of the competitors ran it in under 2 hours and 30 minutes.

For some people, the marathon is not long enough, so they run ultra-marathons over far greater distances. The ultimate ultra-marathon is considered to be the Western States Endurance Run in California. The course is 161 km long, passing through snow drifts and rivers from Squaw Valley to Auburn.

It is a gruelling race, combining up-hill and downhill running. In order to be allowed to participate in the race, the applicants must pass a rigorous physical examination and have run an 80 km race in less than 10 hours.

With temperatures in Auburn nearing 38°C it is important that the competitors do not lose too much water, so their weight is monitored at various points in the contest. If they lose more than seven per cent of their body weight a competitor must withdraw from the race as he or she is dehydrating too much. The official cut-off time of the race is 30 hours and a special prize is reserved for anyone who manages to complete it in less than 24 hours.

The triathlon

More gruelling than just running, the triathlon is a race that combines long distance swimming, cycling and running. The most established triathlon event is the Hawaii Ironman, where competitors have to first swim 3.8

The Grand Marathon of Los Angeles, covering a distance of more than 42 km, is held every year. Runners plus dogs and babies take part.

The Paris-Dakar Rally covers 11,416 km. 265 cars, 140 motorcycles and 100 trucks took part in 1990. Only 87 of the cars and 46 of the motorcycles finished the race.

Just amazing!

HOT MOTOR

REIGNING CHAMPION ARI VATANEN'S HOPES OF WINNING THE 1988 PARIS-DAKAR RALLY WERE DASHED WHEN HIS CAR WAS STOLEN FOR FIVE HOURS AND HE WAS DISQUALIFIED.



Paul Raymond

km, then cycle 180 km and finally run a full marathon of 42.195 km. America's Mark Allen has done the course in 8 hours 7 minutes and 45 seconds.

The earliest car rally was from Peking to Paris in 1907. The chauffeur-driven winner covered the 10,000 km in two months. Seventy years later came the longest ever rally, from London to Sydney, a distance of 31,107 km taking around six weeks. The longest annual car rally is the Safari Rally, which, at its longest, has covered 6,234 km.



Gamma/Frank Spooner Pictures

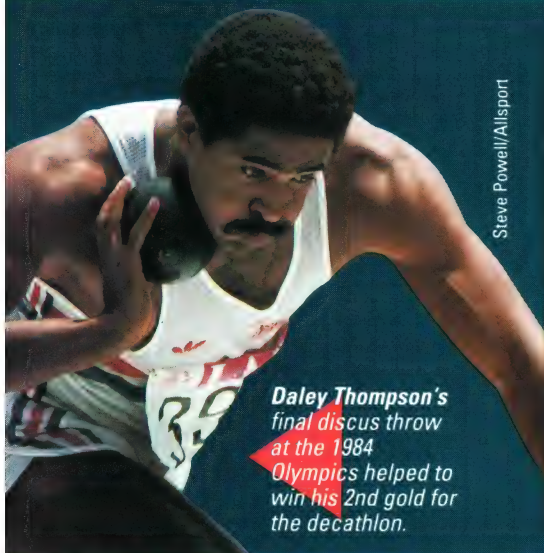
One of the most notorious motor races is the Paris-Dakar rally, which travels through the Sahara Desert in North Africa, but many spectators and competitors have been killed or injured in the past.

The ultimate in racing is to go all the way around the world. The Round the World yacht race is held every four years. It begins and ends at Portsmouth, UK, with stops and re-starts five times. The fastest time taken over the 59,326 km distance, not including breaks, is 120 days.





VIEW GREAT SPORTING MOMENTS



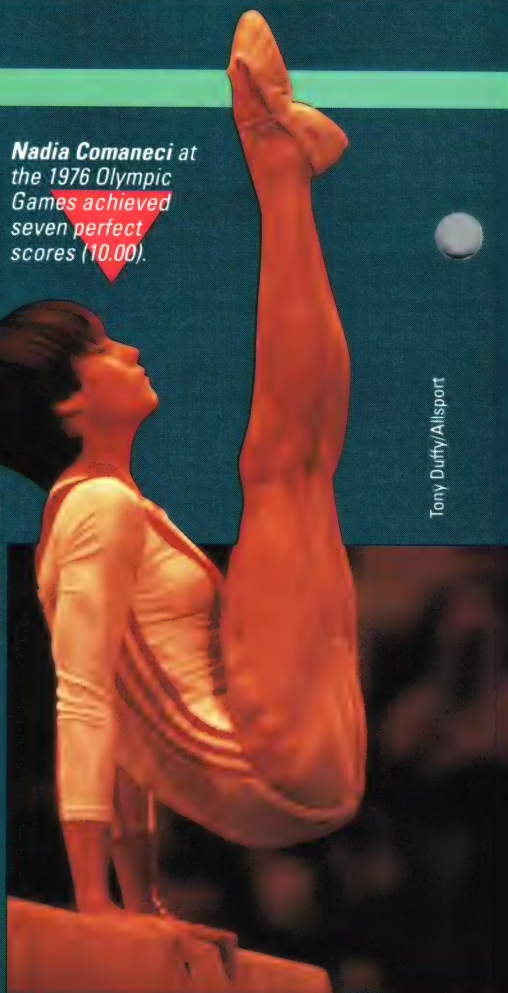
Steve Powell/Allsport

Daley Thompson's final discus throw at the 1984 Olympics helped to win his 2nd gold for the decathlon.



Steve Powell/Allsport

Bjorn Borg of Sweden won his fifth consecutive Wimbledon title as men's singles champion in 1980.



Tony Duffy/Allsport

Nadia Comaneci at the 1976 Olympic Games achieved seven perfect scores (10.00).



Tony Duffy/Allsport

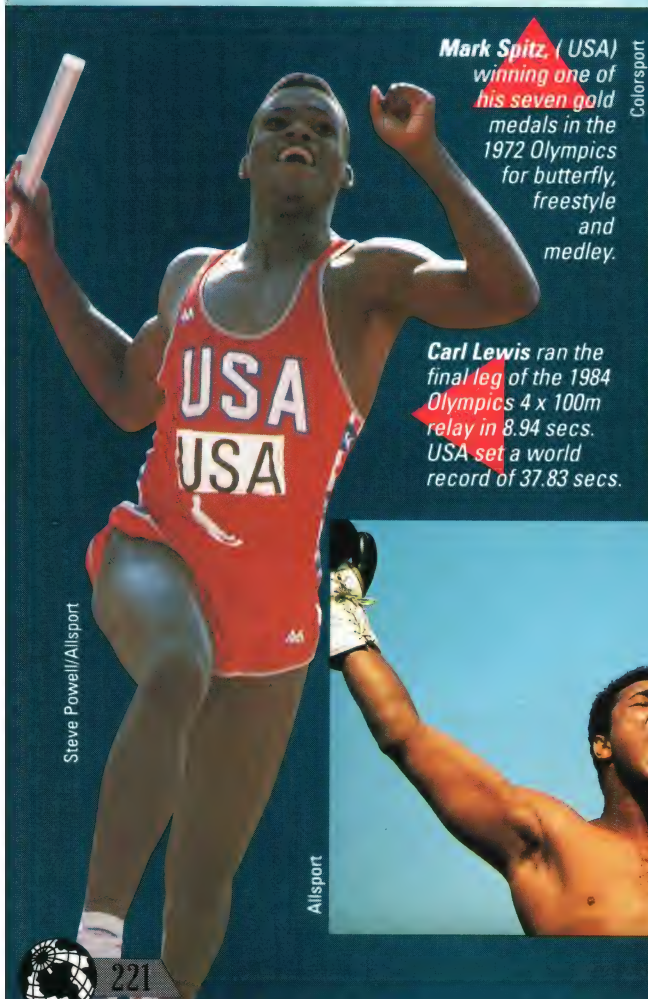
Mark Spitz (USA) winning one of his seven gold medals in the 1972 Olympics for butterfly, freestyle and medley.

Colorsport

Carl Lewis ran the final leg of the 1984 Olympics 4 x 100m relay in 8.94 secs. USA set a world record of 37.83 secs.



Ian Botham at Lord's against Pakistan in 1978 became the first player to take eight wickets and score a century in the same test.



Steve Powell/Allsport

Allsport



Muhammad Ali regaining the world heavyweight title for the second time (the only boxer to ever do so) after beating Leon Spinks on 15 September 1978 – six months after his earlier defeat by Spinks on points.



Adrian Murrell/Allsport

Q ROCKET CAR

Q RAMP-JUMPING

Q SKI-PARACHUTING

IT'S A MAD MAD WORLD



Rex Features Ltd



DIVING INTO BURNING OIL, skiing down Everest or being blasted out of a cannon – there is always someone willing to risk life and limb to enter the record books.

Some of the most spectacular and popular record-breaking attempts of recent years have involved motorcycle jumps. Evel Knievel, an American

former stunt rider, was a pioneer of the motorcycle long jump. He set records for the distances cleared by a speeding motorcycle taking off from a raised ramp.

The combination of a high-speed and an angled take-off allowed him to clear great distances, often accompanied by jumping through hoops of flaming fire. Knievel, however, didn't

Alain Prieur's motorbike jump from a 2,000 metre-high mountain went wrong when one of his two parachutes failed to open – fortunately it was the one on his bike.

Power-lifter Rick Brown, known to his friends as 'Grizzly', holds back two accelerating 750cc motorcycles, each with a pull of 1,270 kg.

only break records – he has also broken most of the major bones in his body, with over 433 fractures.

In 1974 Knievel reached the high point of his dangerous career – by attempting to cross the 485-metre-wide and 180-metre-deep Snake River Canyon in Idaho, USA, in a rocket car. His revolutionary vehicle – *Sky Cycle X2* – was powered by steam, heated to 370°C. This was designed to provide a thrust of 2,268 kg – enough to catapult Knievel some 1,000 metres beyond the far edge of the canyon, where he would be eased down a by a parachute deployed in flight. At least, that was the theory.

Canyon wall

Everything went to plan as *Sky-Cycle* took off and appeared to be making a smooth ascent. But suddenly a weakness in the metal cover caused the parachutes to open prematurely. The vehicle hit the side of the canyon wall as it plummeted down, slowed fortunately by the chutes before it hit the bottom. Rescuers pulled Knievel into a boat – he was cut only on the right cheek and on the lip.

Rex Features Ltd



The longest distance achieved in motorcycle ramp jumping was 76.5 metres in 1991. The record for ramp jumping in cars is 70.73 metres. It was achieved by Jaqueline de Creed in a Ford Mustang in the UK in 1983.

This is only 20 metres further than the record for a human cannonball. Circus performer Emmanuel Zacchini was fired 53.3 metres from a cannon in New York in 1940, with the muzzle velocity estimated at 87 km/h. An experiment that took place in England showed that a 17-year-old girl who was fired from a cannon was 9.5 mm shorter after she landed!

Since the advent of flight, aeroplanes have been used for all manner



Simon Ward/Allsport

Sky-divers in the head down, free-fall position can reach a speed of 300 km/h. At higher altitudes, where the air is much more rarefied, speeds of 1,005 km/h have been recorded.

Helen Tempest set a world record when she flew on the wing of an aircraft for 2 hours 40 minutes. During her act she is sometimes subjected to four times the force of gravity.

ground metal per day, and claims to have eaten ten bicycles, seven television sets, a supermarket trolley and a Citroen car by grinding them down into filings and swallowing them.

However, the Guinness Book of Records has refused to accept any further such entries because of the obvious dangers of trying to outdo Monsieur Mangetout.

French feats

The French appear to revel in setting outlandish records. Although there are many trapeze artists in the world, nobody has ever performed at a greater height above street level than Frenchman Phillipe Petit. He crossed a distance of 42.6 metres between the twin towers of the 411-metre-high World Trade Centre in New York City, reaching the tightrope from the 110th floor of the building.

The first man to have crossed the Niagara Falls on a tightrope was also French – Francois Gravelet, better known as Blondin, as long ago as 1859. He walked 335 metres on a 76 mm thick rope, which was suspended 48.75 metres above the falls. In 1860 he performed the same feat, this time carrying a man on his back.

Yet another Frenchman holds the tightrope endurance record. Henri Rochetaud was 47 years old when he spent 185 days on a 120-metre-long

a combined pull of 612 kg.

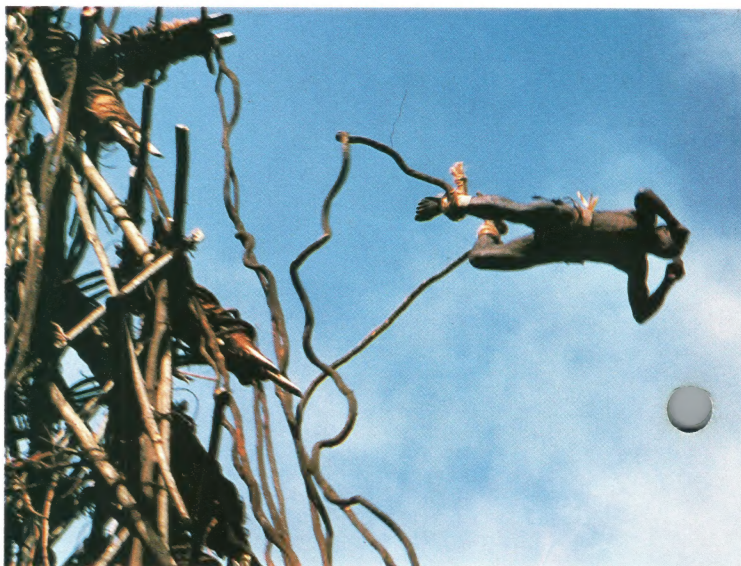
Dave Brunt of Staffordshire went one further when he managed to pull a BAC 1-11 airliner 22.86 metres at Birmingham Airport, UK, in 1986.

Pulling aeroplanes along is one thing, eating them is another. Frenchman Michel Lotito, known as Monsieur Mangetout – literally 'eat everything' – ate a Cessna light aircraft in Venezuela. He has the unique ability to consume up to 900 g of

Sky-divers from all over Australia drop in on the town of Katherine once a year for a week-long 'parachute party'. For added thrills, many of the intrepid high-fliers jump at night.

Men of the Wanur tribe 'Jump for Joy' – a tradition that involves hurling themselves off a 30-metre-high scaffold with their ankles attached to vines that only just prevent them from hitting the ground.

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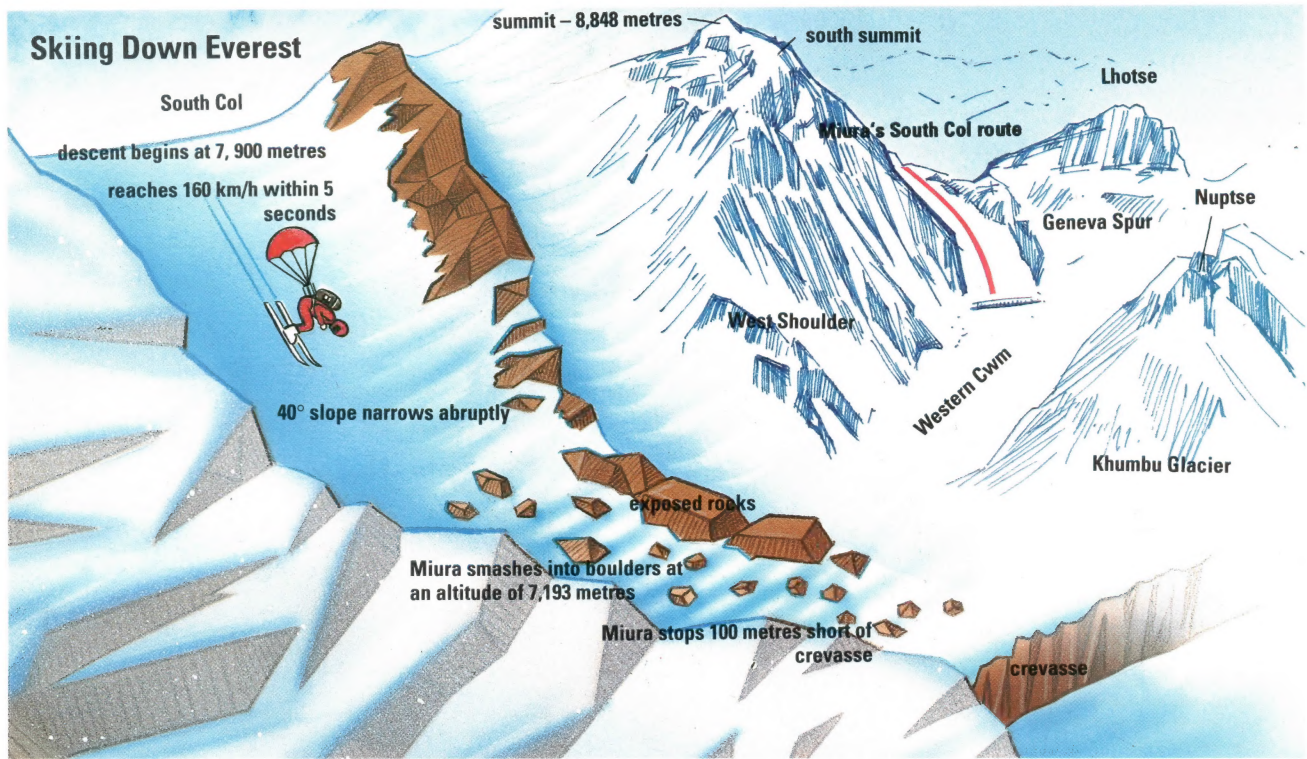
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of death-defying feats. Pushing, pulling and standing on aircraft wings during flight are popular pastimes for potential record-breakers. One of them, Dave Gauder, delayed the take-off of two Piper Cherokee light aircraft by holding two tow ropes, sustaining





Simon Critchley

wire suspended 25 metres above a supermarket in St Etienne in France. Doctors have still not been able to work out how he managed to sleep during this time!

Height has presented challenges in many different ways. Mount Everest, the highest mountain in the world at 8,848 metres, has been the venue for a number of climbing record at-

Yuchiro Miura narrowly escaped death in his attempt to ski down Everest when he lost control and stopped 100 metres short of a crevasse.

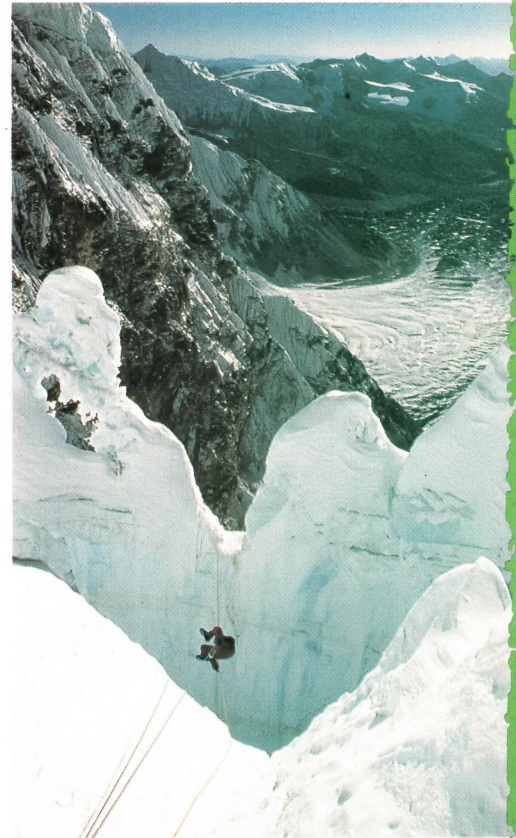
tempts. The summit of Everest was reached in 1953 by Sir Edmund Hillary and Sherpa Tensing.

Ski devil

In 1970, however, Yuichiro Miura attempted something that many people thought impossible – to climb to the summit, then ski down it. Trained as a speed skater, Miura had skied 3,776 metres down Mount Fuji in Japan before tackling Everest, using a parachute to slow him down at the end. His theory

Stephen Venables
– the first British climber to climb Everest without oxygen – crossed this gaping crevasse ten times.

Evel Knievel failed in his intrepid bid to cross the 485-metre-wide Snake River Canyon, USA, in a steam rocket but survived thanks to parachutes slowing down his descent.



was that he would be able to reach greater speeds and descend steeper slopes if he had a way of slowing himself down at the end of his run. Otherwise he would risk overshooting and running off the edge.

He carried out experiments with parachutes at the National Air Force Laboratory in Japan, and in 1966 he successfully negotiated Mount Fuji using the parachute to decelerate at the end. Three years later he tested this technique halfway up Everest.

Stephen Venables



Rex Features Ltd



Finally, in 1970, he set out to climb to the summit of Everest and then ski down it. Many mountaineers thought he was insane to attempt to ski down the mountain, especially as one of the faces he intended to descend was an icy slope with an almost vertical drop of 1,300 metres. It was so steep that even experienced mountaineers would take long detours to avoid having to climb it.

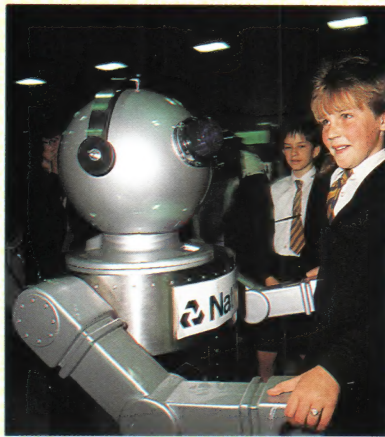
Blue ice

With great difficulty, he climbed to the South Summit, reaching a height of 8,082 metres with his skis strapped over his shoulder. Beyond this height the ice was blue and unskiable. He then skied 1,500 metres in a wide, curving run down to a point known as South Col. There he took off his skis, put on his oxygen mask and climbed to the next, and most dangerous run. He could not ski straight down to the bottom of the slope because there was a crevasse running across the line of the run before the end.

He would need to stop before he reached the crevasse, and he calculated that he would be going too fast to stop in the usual way, by turning the edges of his skis into the snow. The parachute would be needed to slow him down, but at such an altitude the air is thin and the parachute would not open properly unless he was going at least 175 km/h when it opened.

Unfortunately for him, the wind was blowing down rather than up the

ROBOT RECORD-BREAKERS



Record-breaking feats of skill and endurance are not confined to humans, a fact proven by the first ever 'Robot Olympics' held in Glasgow in September 1990. Designers from all over the world gathered to display their latest models. The robots competed in traditional events such as sprinting and javelin – as well as some not-so-traditional activities such as obstacle avoidance, speech and manoeuvrability. One of the most popular robots was the British-designed 'Ralph' (left) who sang and danced. The youngest entrants were pupils from a Scottish Primary School who built a robot (below) that negotiated its way round a house.

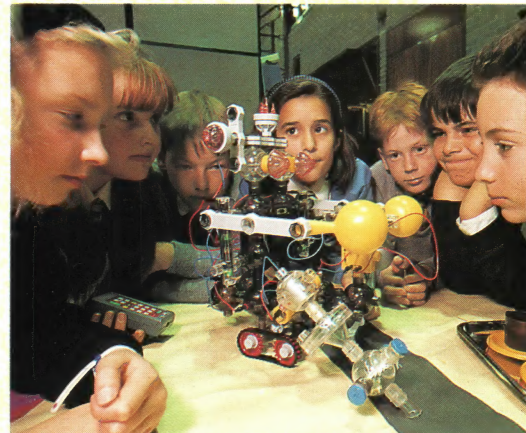
John Paul Photography

mountain into mid-air, releasing the skis and then parachuting down the mountain to safety.

Hitting the target

The most suitable point for take-off was Mount El Capitan in the Yosemite Valley in California, which is nearly 1,000 metres high. Previously, two people had jumped off the edge with parachutes, but they were too close

Nick and Dick Crane approach the summit of Kilimanjaro to set a record for the world's highest cyclists. Their record was broken on Mount Aconcagua in 1994.



Peter Inglis/Dick & Nick Crane

slope, so that when he released the parachute, it failed to slow him down sufficiently. However, he hit a bump and fell, losing his skis and tumbled down until he finally stopped just 100 metres from the crevasse. He had skied down Everest and survived.

American Rick Sylvester took Miura's idea one step further. He pioneered the sport of ski-parachuting, which involves skiing off the top off a

to the wall of the mountain and had hit it all the way down, leaving both of them badly bruised and one crippled.

To solve this problem, Sylvester had a specially prepared ski run built at the top, so that he skied 200 metres down a slightly inclined ski slope at an estimated speed of 80-90 km/h before taking off the edge.

Once in the air he had to release his skis and try to find the correct fall po-

sition with his stomach facing towards the ground and then, halfway down, he had to pull the ripcord to open his parachute.

When he was within about 8 seconds of hitting the ground, he released his parachute and although he did not reach the desired landing place he became safely snagged in a tree, from which he fell to the ground. Two weeks later he attempted the same jump again and safely landed on the dead centre of the target.

Just amazing!

EAT YOUR GREENS!

NINETEEN-YEAR-OLD AMERICAN, JAY GWALTNEY, ATE A BIRCH TREE THAT WAS 3.35 METRES IN LENGTH AND HAD A 12 CM DIAMETER TRUNK. IT TOOK HIM 89 HOURS.



Paul Raymond